

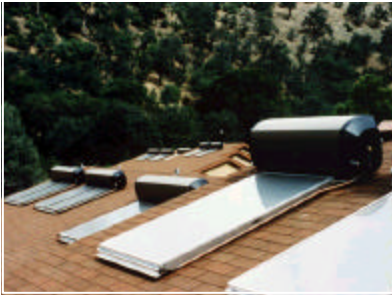


***Photovoltaics History and
Technology
Prepared for the National Parks Service
Steve Butterworth
Energy Manager, West Region
May, 2002***

***Solar Electricity:
The Reliable, Economical, Clean
Distributed Power Solution***



Photovoltaics (PV) vs. other solar - PV converts sunlight directly into electricity



***Distributed
Solar
Thermal***



***Centralized
Solar Thermal***

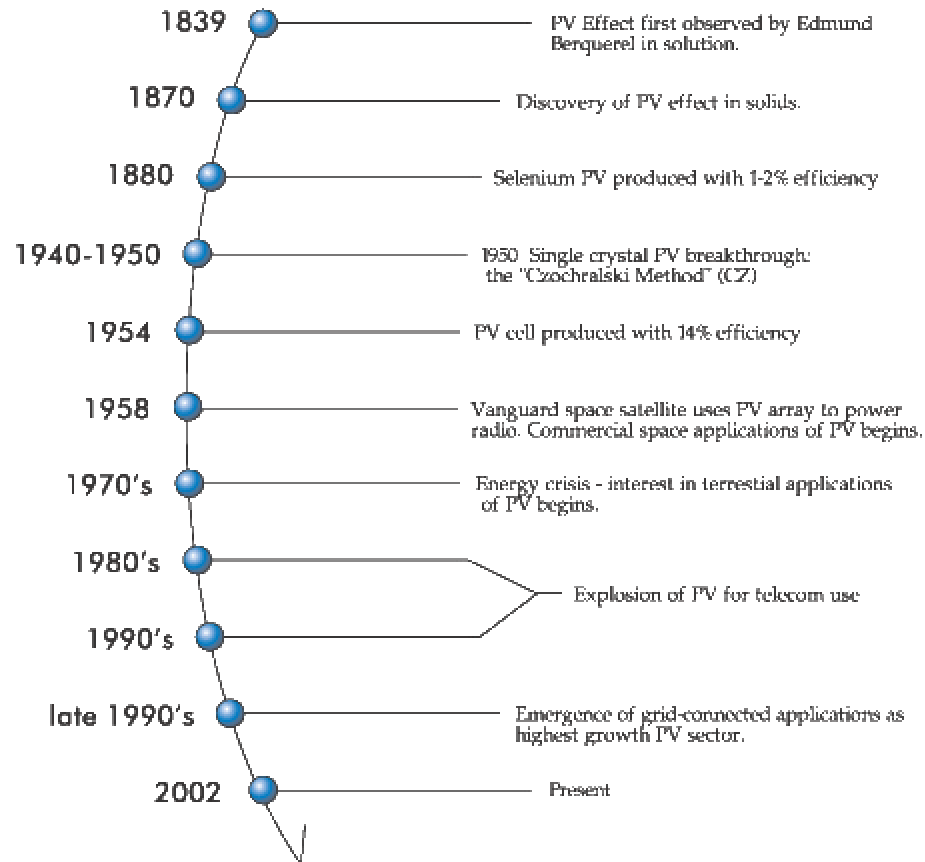


Photovoltaics

Topics Covered

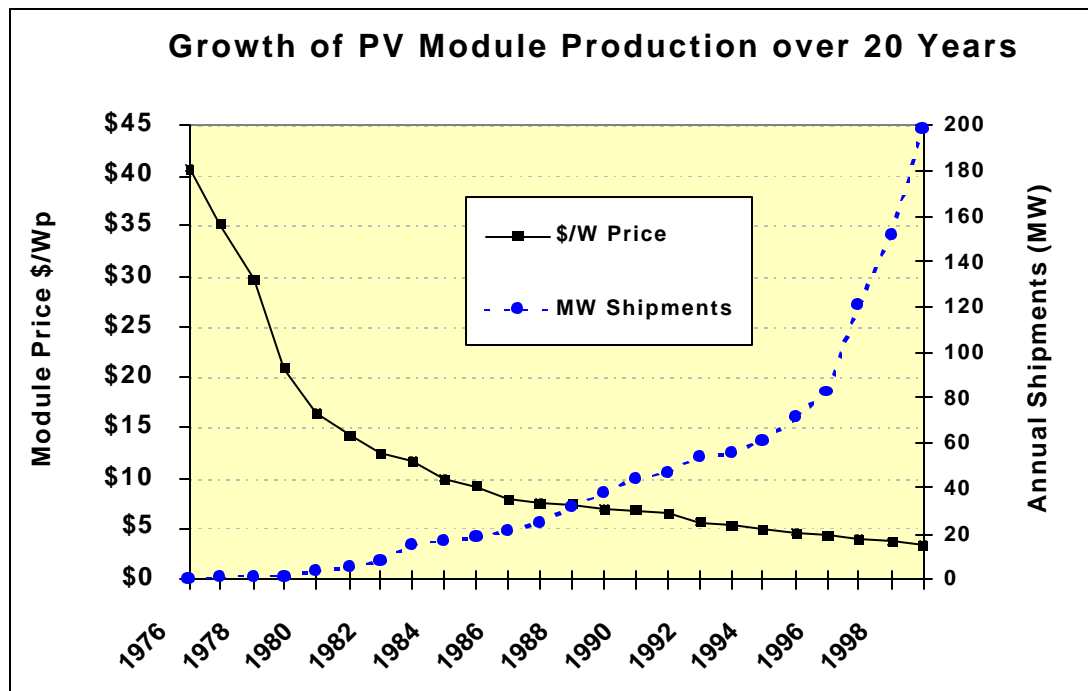
- **History of Photovoltaics**
- **PV Technology Basics**
- **Commercial Grid-Connected Systems**
- **Benefits of on-site PV generation**

PV History Timeline



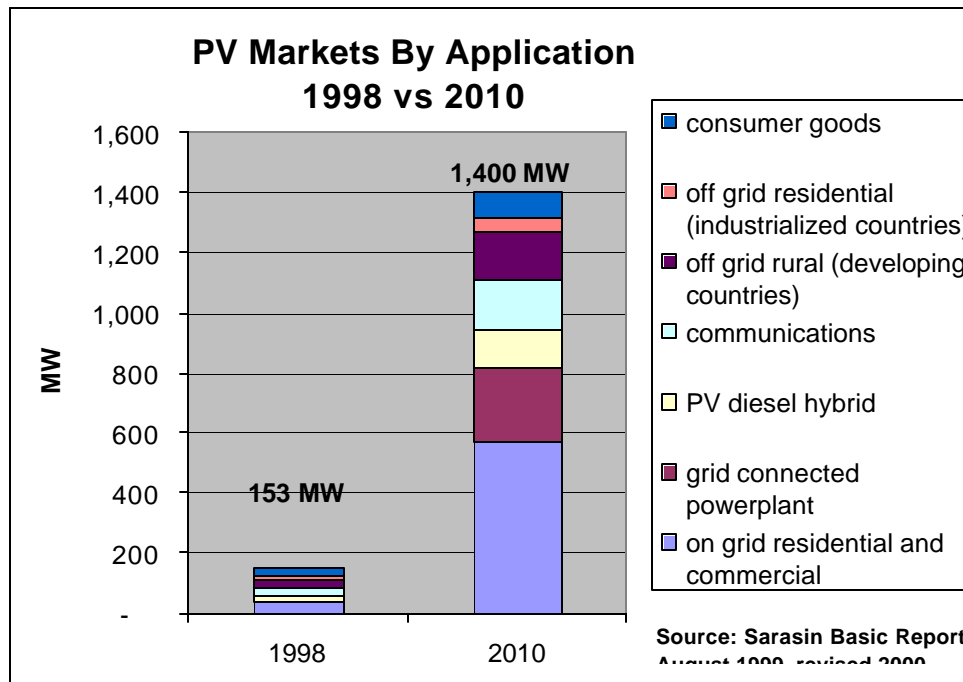
History of PV

PV prices have fallen 10x in the last 25 years



History of PV

Grid-connected systems are now the fastest growing segment of the PV market



**30%+ growth
per year
forecasted**

History of PV

Who uses commercial PV systems today?



Johnson & Johnson



HAYWARD
LUMBER

United States
IBEW Canada



Parker  Ranch



Neutrogena[®] DERMATOLOGIST RECOMMENDED

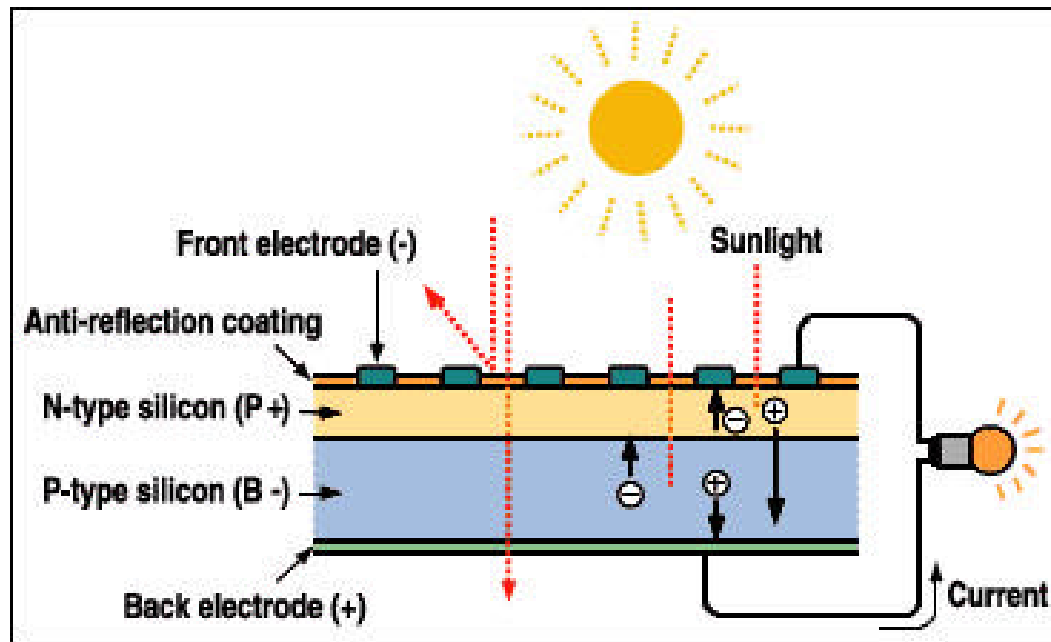


FETZER[®]
VINEYARDS



Photovoltaic Basics

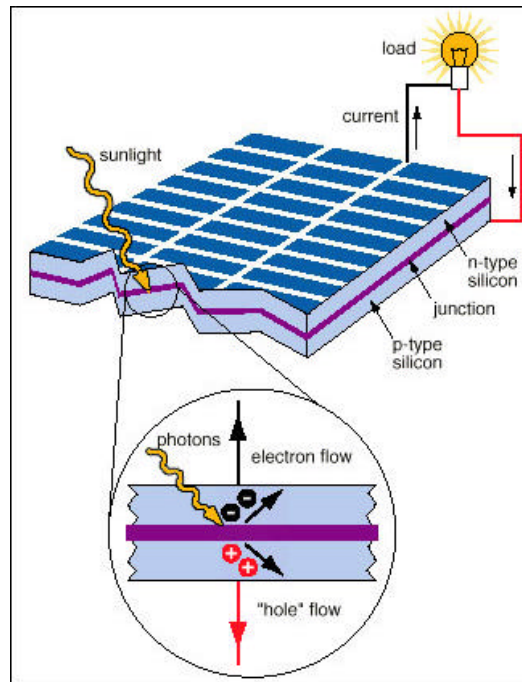
***PV Technology Fundamentals –
“The Photovoltaic Effect”***



Sunlight excites electrons in the solar cell and creates electric current

Photovoltaic Basics

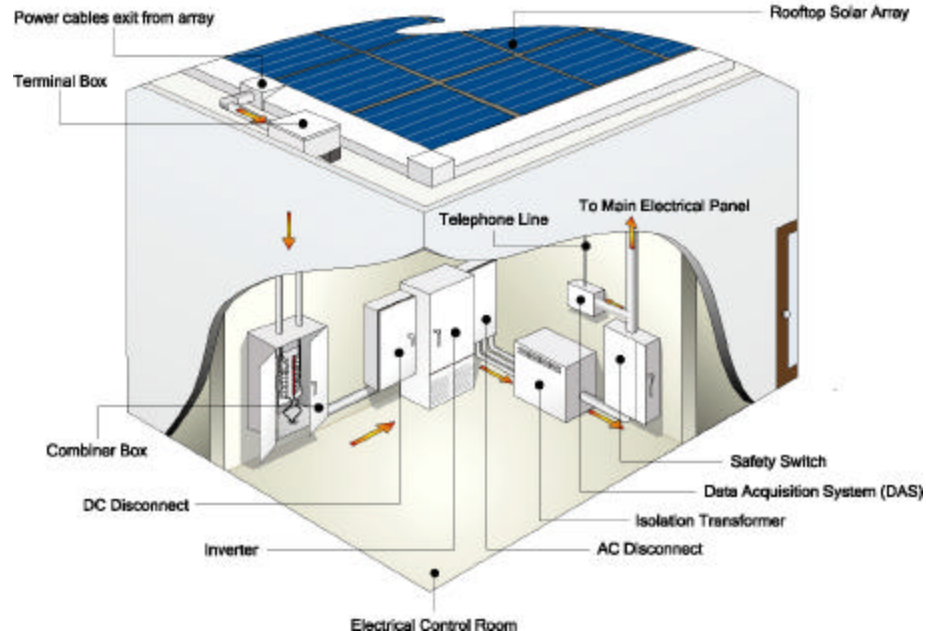
PV cells are connected together to form a module



Commercial Grid-Connected Systems

Basic components of a commercial grid-connected solar system

Solar Electric Array Flowchart



Commercial Grid Connected Systems

Traditional methods of mounting PV on flat, commercial rooftops are problematic



Conventional attachment



Ballast tray

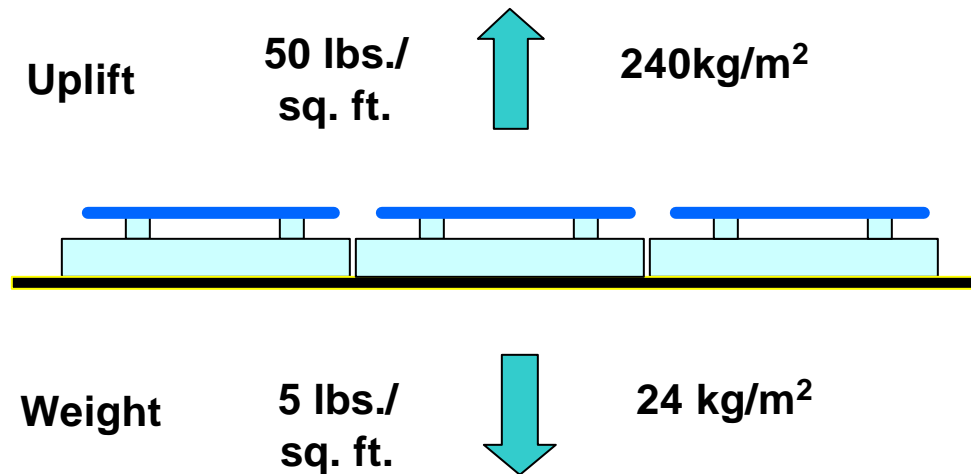
Commercial Grid Connected Systems

PowerLight provides the best mounting solution for commercial PV installations

- **Patented**
- **Lightweight**
- **No penetration**
- **Insulates roof**
- **Protects roof**
- **Pre-engineered**
- **UL listed**



Commercial Grid Connected Systems
Lightweight and wind resistant



Commercial Grid Connected Systems
Palletized shipping and lifting



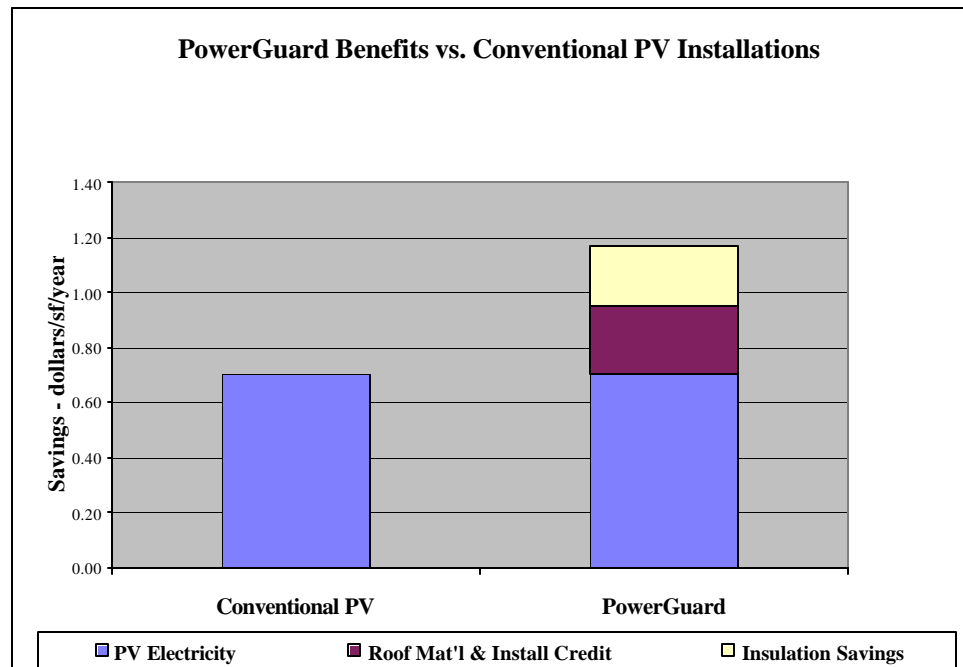
Commercial Grid Connected Systems
Fast non-invasive installation



Commercial Grid Connected Systems

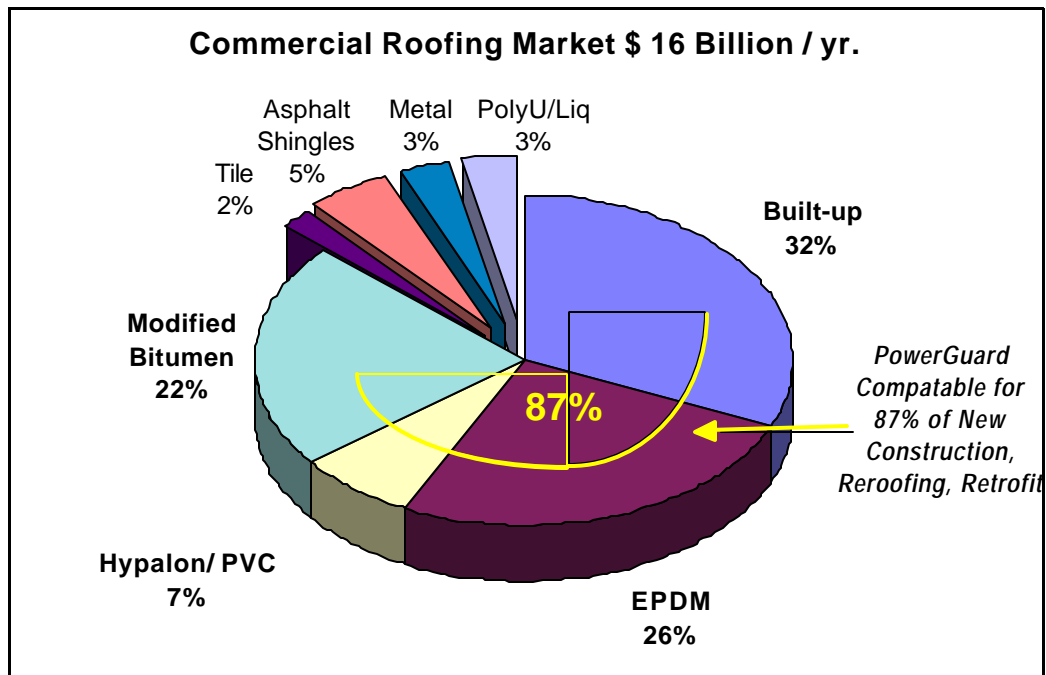
Value advantage of PowerLight rooftop systems

Benefits vs. conventional mounting



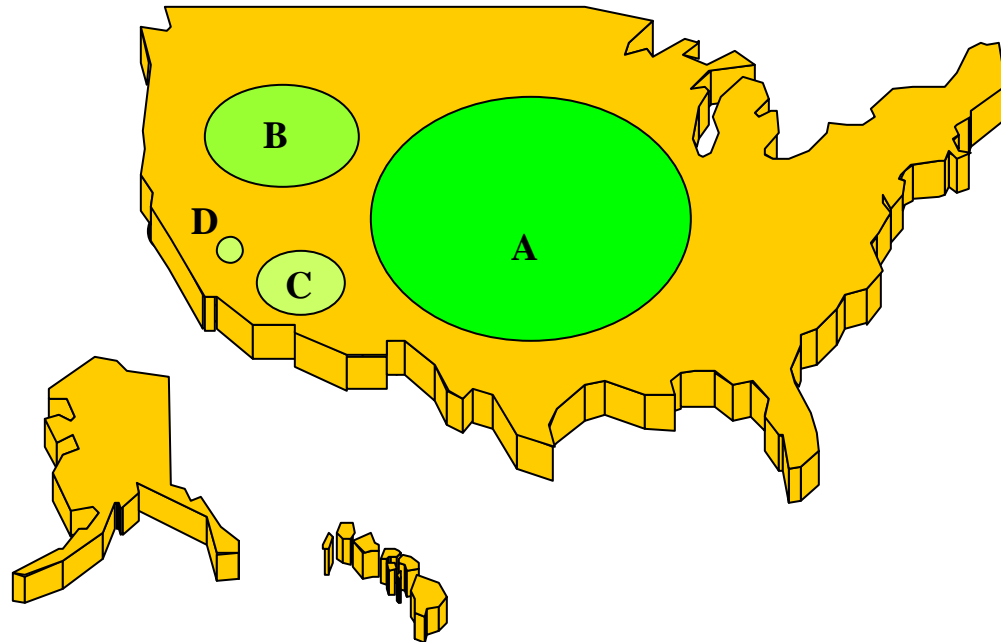
PowerGuard®

Compatible with 87% of existing US roofs



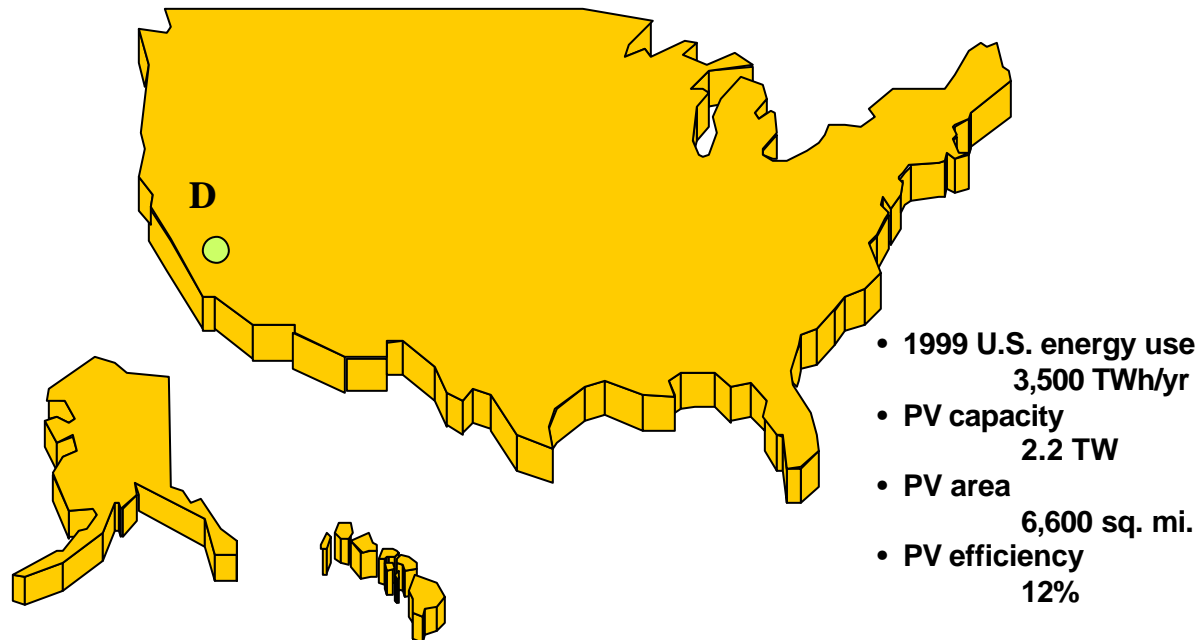
Commercial Grid Connected Systems

What area of PV is required to satisfy 100% of US electrical energy needs?



Commercial Grid Connected Systems

***Area D: PV in a 45-mile radius would serve
total US electric energy needs***



Sources: USEIA

Why the National Park Service Chose to Implement a Solar Electric System

Financially prudent

- 1) Zero fuel costs**
- 2) Financial hedge against fuel price increases**
- 3) Coincident with expensive “peak” electricity**

Reliable

- 1) Proven technology**
- 2) 20 to 25 year warranties on electricity generation**
- 3) Virtually maintenance-free**

Clean

- 1) Zero emissions**
- 2) 100% renewable**
- 3) Over-the-counter permitting**

Safe and Silent

Yosemite Solar Project Summary:

Project Size: 47 kWp, 350 solar electric rooftiles covering approximately 4,500 square feet of the NPS's El Portal Maintenance Facility

Turnkey Contractor: PowerLight Corp.

Product: *PowerGuard* solar rooftop tiles

Generates enough electricity to power more than 45 homes

Reduces National Park Service's peak energy consumption by 10%

Environmental savings:

1,508 tons of carbon dioxide over 25 years

950 lbs of Nox over 25 years

25 lbs of SO₂ over 25 years

Project Economics: 11% IRR or 11 year payback

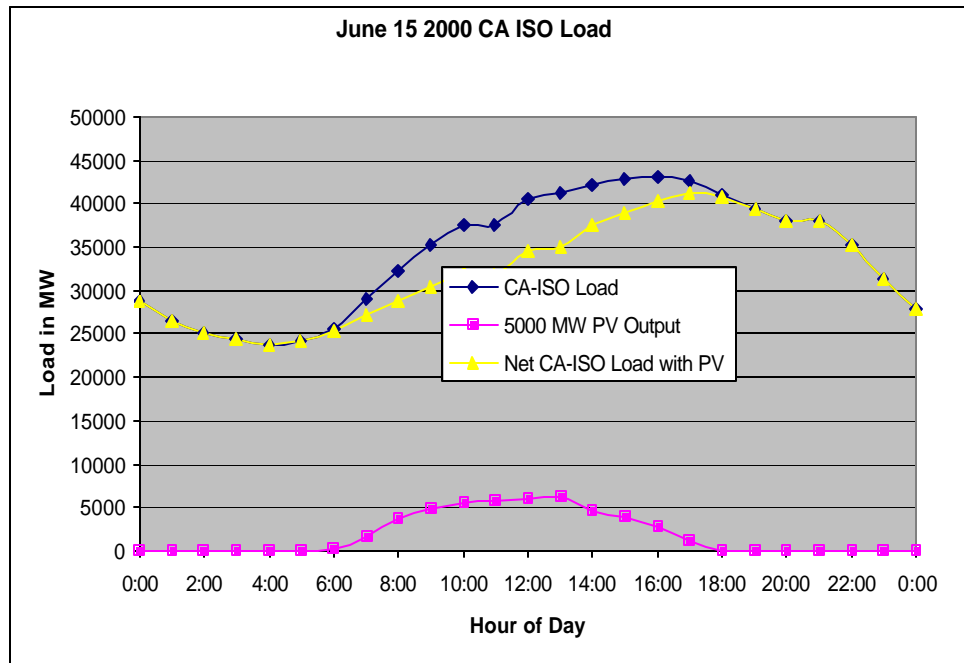
***National Park
Service
El Portal, CA
Maintenance
Facility***

***47kWp
PowerGuard
solar
electric roof
system***



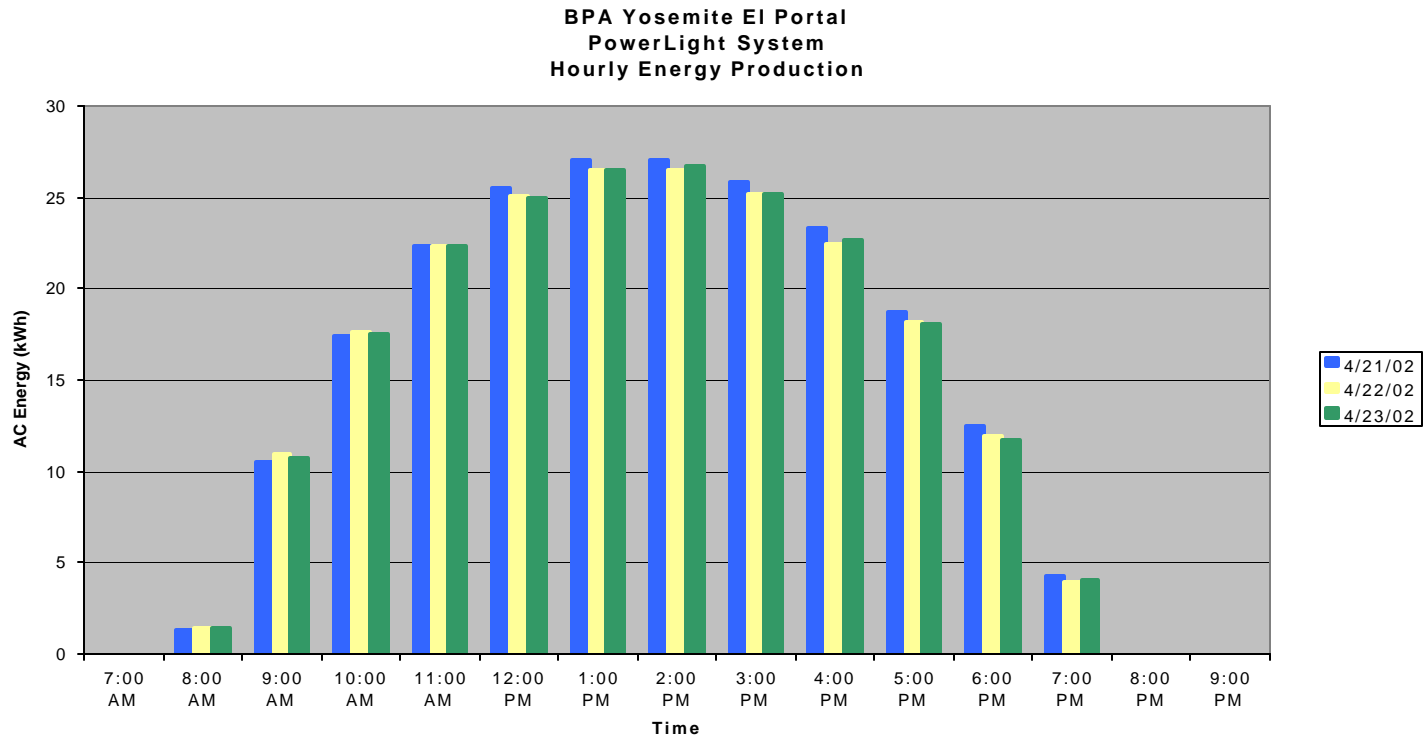
Benefits of onsite PV generation

PV is coincident with peak-power demand, and shaves system peaks



Benefits of onsite PV generation

***PV is a reliable, proven technology,
with highly predictable energy output***



PV is the cleanest energy technology available. The EI Portal system will save:

Offset emissions: 1,500 tons of CO₂ (smog, acid rain)
950 lbs Nox
25 lbs SO₂

Equivalent to:

- Planting trees: 17 acres
- Not driving 3,770,000 miles

PV System Economics

Total system economics has several components

- **Geographic location of the system**
 - 1) Amount of sun available
 - 2) Electricity rates, especially daytime and summer
 - 3) Local PV incentives
- **Savings from total-system benefits**
 - 1) Reduction in electricity costs
 - 2) Extended roof life
 - 3) Thermal efficiency benefits
- **Net system cost**
 - 1) Initial system cost
 - 2) Maintenance costs (virtually none)

PV System Economics

Financial services

- **Design most cost-effective payment structure**
 - 1) **Purchase, when all tax benefits can be used**
 - 2) **Loan, up to 100% financing**
 - 3) **Tax lease, cost-effective if tax benefits cannot be used by owner**
 - 4) **Host system & purchase electricity (3rd-party ownership), more complex. Feasible only in certain states**

- **Considerations**
 - 1) **Source of funds. Operating vs. capital budget**
 - 2) **Cash flow**

Questions to consider for on-site solar

- **How much solar can your real estate support (flat or sloped roofs, parking lots, open land)? 10,000 sq. ft. or more**
- **What is your annual electricity consumption in kWh?**
- **What is your annual electricity cost?**
- **What is your cost per peak kWh?**
- **Do you have solar incentives in your State?**